Safety Study of the Potential Effect of Wainfleet Wind Energy Project on Burnaby Skydiving Operations

SMS Report No. 1307

Produced by

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GLOSSARY

AGL	above ground level
ALARP	A level as low as reasonably practicable
ASL	above sea level
CARs	Canadian Aviation Regulations
CFS	Canada Flight Supplement
CSPA	Canadian Sport Parachuting Association
DZ	drop zone
fpm	feet per minute
ft.	feet
km	Kilometre
km/h	kilometres per Hour
kts	knots (nautical miles per hour)
mph	miles per hour
m/s	Metres per Second (where 1 m/s equals 3.6 km/h)
MW	megawatts
NM	Nautical Mile (where 1 NM equals 1852 m)
NOTAM	notice to airmen
Runway	Rwy
Safety-critical	A term that is used to refer to activities whose failure or malfunction could result in the death or serious injury of participants, employees or members of the public.
TC	Transport Canada
UK CAA	United Kingdom Civil Aviation Authority
VFR	visual flight rules

1. INTRODUCTION

1.1 Background

Concerns have been raised about the potential safety effects of the proposed Wainfleet Wind Energy Project on the operation of Skydive Burnaby west of Port Colborne, Ontario. Consequently, SMS Aviation Safety Inc. has been contracted to conduct an independent, third-party safety study of the issue.

1.2 Purpose

The aim of the study was to determine whether the presence of turbines 4 and 5 of the Wainfleet Wind Energy Project would significantly increase the safety-risks experienced by skydiving operations being conducted at the Port Colborne aerodrome.

1.3 Methodology

1.3.1 Hazard Analysis – General Description of the tool used as the substance of the study.

Para-jumping is a safety-critical activity. Safety management in safety-critical activities is a continuous process of observing a multiplicity of factors and their linear and more importantly non-linear interactions with the objective of identifying potential hazards, prioritizing the potential hazards in terms of their associated risk and then mitigating the risks associated with the potential hazards.

A hazard analysis is a qualitative assessment of the risks associated with the hazards that develop in and around a safety-critical activity. Risk is expressed as a function of the potential severity of a safety incident should it occur and the likelihood of the safety incident occurring. Severity is subjectively classified as:

- Category A – Potential for loss of life or destruction of property and equipment.
- Category B – Potential for serious injury or damage to property and equipment.
- Category C – Potential for minor injury or damage to property and equipment.
- Category D – Trivial (e.g. inconvenience)

Likelihood is subjectively classified as:

- High – occurs often
- Medium – occurs occasionally
- Low – occurs seldom
- Rare – occurrence is unlikely
- Very rare – occurrence is highly unlikely

In order to be able to mitigate the risk(s) associated with potential hazards that could negatively affect a safety-critical activity a six step process is followed:

1. Brainstorming of possible event scenarios (the events that could lead to a safety incident/accident). In conjunction with this step priorities are assigned to categorize the most likely and most sever;

2. Identification of potential hazards and the risks embedded in the even scenarios;
3. Categorization of similar events and similar hazards;
4. Development of mitigation strategies;
5. Determination of risk severity and likelihood post mitigation application; and
6. Documentation.

Though the process is subjective, quality results are achieved through the use of experienced methodologists and subject matter experts who are thoroughly knowledgeable about the safety-critical activity.

1.3.2 Application of hazard analysis process in support of this study.

A hazard analysis of the potential effect of the Wainfleet Wind Energy Project on Burnaby Skydiving Operations was conducted. The resulting document distilled information concerning:

- The operations of Skydive Burnaby;
- The proposed Wainfleet project;
- Relevant primary and secondary source materials, including standards or best practices related to the siting of turbines vis-à-vis aviation and skydiving operations; and
- Accident and incident data.

Three categories of hazards were identified:

- Those that currently exist in the skydiving operation, and would not be affected by the proposed turbines;
- Those that could exist in the future and currently do not exist; and
- Those that currently exist, and which potentially could experience increased risk due to the presence and operation of the turbines.

An operational safety review team was formed to conduct the study. The team comprised individuals with expertise in operational risk management and assessment, small aircraft operations and skydiving operations. A summary of their operational experience is contained in Appendix A. They identified and validated the hazards, identified the associated risks, assessed the severity and the likelihood of the related risks, and where appropriate, suggested mitigating measures.

1.3.3 Definitions

The following definitions were employed:

- Hazard: A condition or circumstance that has the potential to cause a loss of property or serious physical injury, including loss of life.
- Risk: The consequence of a hazard, measured in terms of severity and likelihood.
- Mitigation: The measures taken or available to eradicate or reduce the exposure of a hazard, or to reduce the likelihood or severity of a risk.

1.3.4 Limitations of information and data

Information concerning skydiver fatalities referred to in this report was a result of queries to the Civil Aviation Daily Occurrence Reporting System (CADORS). CADORS is a Transport Canada (TC) program that records in an online database aviation incidents and accidents within Canada. The CADORS includes a variety of events, including accidents, incidents, suspected CARs non-compliance, missing aircraft, emergencies of all types related to aircraft including passengers, etc. The information comes from a variety of sources such as police agencies, NAV Canada, aircrew, etc. CADORS reports are considered reliable sources of information concerning aviation activities and the information related to fatalities is considered complete.

However, due to several factors the CADORS information related to skydiving injuries is not complete. Reporting of skydiving injuries is voluntary, the information when recorded is generally minimal, and the use of CADORS for injury reporting is rarely used by the skydiving community. In addition there is no requirement for the long-term retention of injury records by neither skydiving clubs nor the CSPA resulting in annual purging of such information.

In addition the effects of wind turbines on aviation and in particular skydiving operations have not been fully studied. Consequently, there is little information on some subjects (e.g., air turbulence downstream of turbine blades), and that which exists is sometimes contradictory.

1.4 Report Structure

Section 2 provides contextual information of the system that was studied by the operational safety analysts.

Section 3 contains the results of the study.

Section 4 contains a summary and conclusions.

2. DESCRIPTION OF THE SYSTEM UNDER REVIEW

2.1 Introduction

This section provides information that is pertinent to the operational analysis reported in Section 3. It includes general information about the Wainfleet Wind Energy Project, the airfield and aircraft operations that support the skydiving operation, the skydiving operation itself, wind information and accident and injury data.

2.2 Wainfleet Wind Energy Project

The Wainfleet project comprises five Vestas V100-1.8 MW turbines, each equipped with a 100 metre diameter rotor consisting of three blades and the hub atop a 95 metre tower. Based on the prevailing wind conditions, the blades are continuously positioned to help optimize the pitch angle.

Turbine 4 (N42 52 36 W79 22 29) and turbine 5 (N42 52 49 W79 22 30) are located approximately 1.7 kilometres west of the Port Colborne aerodrome. The towers are spaced 430 metres apart on a north-south axis. T4 and T5 are located 130 metres and 98 metres east of Station Road, respectively.

2.3 Aviation Operations at Port Colborne

2.3.1 Airfield information

According to the Canada Flight Supplement (CFS), also known as GPH 205[1], Port Colborne has been assigned the identifier CPE5. It is a privately owned, registered aerodrome located at N42 52 39 W79 21 10 with a field elevation of 600 feet above sea level (ASL). There are two runways: Rwy 03 and Rwy 21. Due to predominantly westerly winds Rwy 21 is normally active (approximately 70% of the time). Due to another aerodrome located 2 nautical miles (NM) to the east all traffic patterns flowed to Rwy 21 are right-hand, which means when aircraft approach the aerodrome for landing they must approach from the western side of the runway. The altitude for aircraft in the traffic pattern is 1000 feet above ground level (AGL) until on base leg (ANNEX B has a diagram of a standard aircraft traffic pattern).

The aerodrome is operated for the exclusive use of Skydive Burnaby, and transient pilots wishing to land must obtain prior permission.[2] All pilots flying at or below 3600 feet ASL are expected to contact the aerodrome on a discreet frequency prior to approaching a 5 nautical miles (NM) radius from the aerodrome. Aeronautical charts and publications indicate the presence of skydiving operations immediately above the airfield at altitudes between 2800 and 11,500 ASL. The area is called CYA513(P).

Occasionally the aerodrome could be used:

- As a destination for transient aircraft that have received prior permission from Skydive Burnaby. The pilot of a transient aircraft is required to contact the aerodrome operator in advance and request permission to use CPE5 as a destination.

- For pilot proficiency checks, training or annual check-rides in support of Skydive Burnaby pilots (on these occasions the aircraft may be flown without any skydivers on board); or

[1] CFS/GPH 205 is a joint NAV Canada and Canadian Armed Forces publication in which all certified and registered aerodromes are list and general information concerning the specific operations at each aerodrome is published. This document is published every 56 days and is authoritative.
[2] Canada Flight Supplement, effective 27 June 2013, Port Colborne, Ontario (ANNEX C has an excerpt of the CFS for Port Colborne).

- As a point of departure for Skydive Burnaby aircraft that are transiting to an aircraft maintenance facility.

2.3.2 Aircraft operations[3]

Almost all skydiving operations by Skydive Burnaby are conducted from a piston-powered Cessna 182 (C182) and a turbo-prop Cessna Caravan (C208). Both aircraft types are operated single-pilot. The C-182 may carry four to five jumpers, and the C-208 fourteen or more. There are three commercially licensed pilots who operate the Skydive Burnaby aircraft.

Standard operations: Prior to take-off, the pilot will obtain the aviation weather forecast, including the surface wind and winds at 3,000', 6,000' 9,000' and 12,000' ASL. They will use this information to calculate the location of the expected SPOT (the location above the ground where the skydivers will exit the aircraft), to plan a climb strategy, and to determine the direction and location of the JUMP RUN[4]. Skydivers will board the aircraft then the pilot will take-off and climb into wind. Upon reaching 500 feet AGL (or higher) the pilot will turn the aircraft in the direction of the SPOT and continue to climb at the aircraft's maximum rate of climb.[5]. They continue to fly a maximum rate of climb to the drop altitude. The JUMP RUN is normally aligned into wind and the actual jump made at the previously determined jump SPOT. Once the skydivers leave the aircraft, pilots normally descend rapidly (1800-3000 fpm) while turning towards the airport. When airport traffic permits the pilots will fly an abbreviated circuit directly to base leg for the landing runway, which normally will position the aircraft to the north-north west of the runway.

2.4 Skydive Burnaby Operations

2.4.1 General

Skydive Burnaby is a well-established skydiving operation that regularly attracts parachutists from across south-western Ontario and north-western New York. The owners report that as many as 10,000 jumps occur during a busy season, which generally extends between March and November. Most activity occurs during the summer months. The facility provides a variety of training that attracts novice jumpers and those seeking licences as high as a Level D licence. They host numerous annual events.

2.4.2 Skydiving operation

Tandem jumps — where an instructor is secured to a student jumper under a large, steerable canopy — are exclusively employed with novice jumpers. Tandem jumps in Canada are typically initiated from altitudes of 11,000, 13,000 or 14,000 feet ASL, with parachutes usually deployed at approximately 5000 to 6000 feet AGL. Normally, all tandem skydivers exit the aircraft during a single JUMP RUN. Licensed and expert skydivers will of course employ a single canopy. Depending on their experience and inclination, they may conduct precision flight or landing manoeuvers, singly or in

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[3] Aviation operations in support of skydiving is categorized by Transport Canada (TC) as Commercial Air Services performing Aerial Work and must meet the conditions and operations specifications in an air operator certificate issued to that operator by the Minister of Transport.

[4] The preferred location for the SPOT is normally upwind from the landing location at a distance which, if the skydiver took no action after exiting the aircraft, would result in the skydiver drifting with the wind to the drop zone. The drop zone for Burnaby skydiving activities is normally the aerodrome. The JUMP RUN is the final track the aircraft flies immediately before the skydivers exit the aircraft. Skydivers prefer to have a JUMP RUN aligned into wind, meaning the aircraft flies in the opposite direction in which the wind is blowing (if the wind is blowing from the west to the east, then the jump run will be flown from the east towards the west. This practice reduces the ground speed of the aircraft, allowing more time for the skydivers to exit the aircraft over the area of the SPOT.

[5] Procedures may vary. The climb may be a straight course into the forecast wind, with wings level to maximize lift and few turns to minimize drag, followed by a single turn towards the DZ. Or, the climb might be box-shaped to stay close to the DZ, or to avoid adjacent airspace.

formation with a number of other skydivers. The aircraft requires a minimum flight visibility of five (5) statute miles when dropping jumpers.

Table 2.1 lists the minimum altitude above ground at which the main parachute must be activated in Canada.

Table 2.1 – CSPA Minima Deployment Altitudes[6]

Category	Minimum Altitude (AGL)
Tandem jumps	4000' (1220 m)
Solo and A license	2500' (760 m)
All other licenses	2200' (670 m)

All skydive parachutes have a built-in reserve in case the primary malfunctions. Furthermore, at least one of the two chutes worn by a skydiver is equipped with an AAD (automatic activation device)[7], so that if the jumper is incapacitated, the chute will open anyway.

Table 2.2 lists the maximum wind speeds, at canopy height, in which sport parachute jumps may be carried out in Canada.

Table 2.2 – CSPA Wind Maxima[8]

Category	Maximum Wind Speed
Student parachutists	15 mph (7 m/s)
Solo, A & B CoP holders	18 mph (9 m/s)
C & D CoP holders	25 mph (11 m/s)
Tandem jumps	25 mph (11 m/s)
Night and water jumps	10 mph (5 m/s)
Exhibition jumps	18 mph (9m/s)

The amount of time spent free-falling and descending under canopy will vary. However, except when there is an emergency, the parachute descent must be initiated no lower than 2200 feet AGL. Skydivers then "fly the chute" towards the drop zone, positioning themselves to turn a short "base leg" close to the landing site, then turn again to face into wind before landing on or near the DZ.

2.5 Prevailing Winds

Wind conditions are an important component in understanding the potential risk to skydiving operations caused by the proposed turbines. As illustrated in section 3, wind conditions influence air turbulence generated by the rotating turbine blades, as well as the flight patterns of the skydiving aircraft and parachutists in descent.

Seasonal information related to wind direction at rotor height indicates consistent, prevailing winds from the west southwest during all four seasons, and particularly during the summer months when skydiving operations are most frequent[9]. These data are consistent with historical wind data collected at ground level by Environment Canada[10].

[6] CSPA, Parachutist Information Manual, section 2.5.

[7] The AAD is activated by a rapid change in air pressure as the skydiver free falls below a pre-determined altitude. If the parachute is not deployed by a pre-specified altitude, the AAD will deploy the parachute mechanically without assistance from the skydiver.

[8] CSPA, Parachutist Information Manual, section 3.2.

[9] Garrad Hassan, Turbulence Analysis at the Proposed Wainfleet Wind Project, Document no. 800532-CAVA-T-01, August 29, 2013

[10] http://www.windfinder.com/windstats/windstatistic_port_colborne.htm

2.6 Accident and injury data

There have been no reported fatalities or injuries to skydivers in North America that were caused directly or indirectly by wind turbines. Only one fatality has been recorded worldwide, and this was in Germany in May 2000, when a 23-year old parachutist on her first solo jump drifted into a turbine that was 4 kilometres from the intended landing site.

Details regarding parachuting fatalities in Canada and the United States are presented in Appendix B.

Though information regarding non-fatal injuries to Canadian skydivers is incomplete, an examination of 84 injuries reported to the Canadian Sport Parachuting Association (CSPA) in 2012 determined that almost all involved injuries to the ankle, leg and back, and almost all occurred during the landing. The majority of the injuries were experienced by students with less than 25 jumps or who were tandem passengers.

3. ANALYSIS AND DETERMINATION OF RELATIVE RISK

3.1 Introduction

The effect of the proposed turbines on aviation operations and skydiving operations was examined and high level hazards were identified. Some hazards currently exist at the Port Colborne skydiving operation, and it was determined that the risks to some pre-existing hazards will be unchanged if the proposed turbines are constructed. Pre-existing hazards to aircraft operations included:

- Engine-fire,
- Cabin or cockpit fire,
- Inadvertent chute deployment within the aircraft cabin, and
- Aircraft struck by skydiver during exit or descent.

Pre-existing skydiving-related hazards included:

- Non-deployment of parachute, and
- Collision between two or more skydivers above 600 feet AGL.

Other high level hazards were also identified. Some would be the exclusive result of the proposed turbines; while others currently exist, but unlike the first category described above, the proposed turbines would potentially increase the associated safety-risks. For both these categories of hazards, the operational safety analysts determined the risks for each hazard, assessed the appropriateness of current mitigating measures, and considered whether additional mitigation would be required to manage the risks to current levels.

3.2 Potential 'new' hazards resulting from T4 and T5

3.2.1 The proposed turbines are potential obstacles to aircraft and skydiving operations

a. <u>Potential risks to aircraft</u>: Collision with turbine
Loss of control while maneuvering to avoid a turbine

Licensed pilots are responsible for (and commercially-licensed pilots are experienced in) avoiding obstacles when operating under visual flight rules (VFR). In the future pilots operating out of the aerodrome at Port Colborne would be aware of the location of the turbines because of the regulation-required mitigation imposed on the wind turbine owner. Specifically, the turbines will be:

- known obstacles due to the requirement to published their location in NOTAMS (notice-to-airmen), which are read by all aviators;
- physically lighted in accordance with Transport Canada (TC) standards;
- marked on local and regional aviation maps; and
- highlighted in the Canada Flight Supplement (CFS)[11].

Furthermore, the minimum visibility requirement for skydiving (5 statute miles) is considerably more than TC visibility requirements for VFR pilots (3 statute miles). Therefore, pilots carrying skydivers will be better able to identify and avoid the lighted obstacles. Furthermore, visiting pilots will continue to

[11] The CFS is a flight planning document that contains operating information on all registered and certified aerodromes in Canada. In addition to providing information on runways, operational procedures, minimum altitudes, and communications, it cautions pilots on known hazards in the vicinity of an aerodrome – hazards such as the location and height of communication towers, wildlife activity, areas where wind shear is prevalent, and parachuting activity.

need prior permission to land or operate from the aerodrome, and will likely be briefed before arriving or departing the Port Colborne aerodrome on the presence and location of the turbines.

Nevertheless, there would be a potential risk of collision with a turbine, or a loss of control while maneuvering to avoid the obstacle if a pilot experienced an airborne emergency that required an immediate forced-landing. Examples of such emergencies include an engine failure in the climb, or an engine or cabin fire

Assessment of risk to skydiving aircraft

The operational safety analysts determined that the risk of colliding with one of the two turbines, or losing control of the aircraft while avoiding a turbine during an emergency would be rare. They made this determination because:

- The relatively short runway length and the high aircraft operating weights will require pilots to take-off into wind on runway 21 on a heading that takes them away from the turbines;
- The subsequent right-hand cross-wind turn will enable pilots to climb on a track that avoids overflying the turbines while they continue the climb to an altitude well above the turbines[12];
- Once established in a climbing pattern, they will be able to see the two turbines well below them, and in the event of an emergency, find an acceptable field or landing area on which to force land, clear of either of the two turbines, which are separated by almost one-half a kilometer.

It was determined that if there were residual risks, they could be mitigated by developing and adhering to local procedures that ensure pilots remain vertically and laterally clear of the turbines after takeoff and during descent for landing.

b. Potential risks to Skydivers: collision with turbine towers or blades
loss of control while maneuvering near a turbine

It is unlikely that skydivers will need to be directly above the turbines. Prevailing wind velocities (from the west- southwest) will result in the SPOT often being located south or east of the turbines before the skydivers commence their free-fall. When their chutes open the winds will blow them further to the east of the turbines towards the DZ[13].

When the winds are directly from the west rather than the west-southwest, the SPOT will move closer to the location of the turbines. However, on most occasions, the SPOT will lie to the east of T4 and T5.

Table 3.1 depicts the drift that skydivers experience under the chute in different wind conditions. To illustrate, a student will normally descend at approximately 1000/fpm. If a student initiates chute deployment at 3000 feet AGL, they will descend under the chute for approximately 2.5 minutes[14]. If they experience winds that average 20 mph, they will be blown 3520 feet (1.07 kilometers) laterally while descending 2000 feet. This lateral distance does not account for the additional distance that the skydiver will achieve while “flying the chute” in the direction of the DZ. Furthermore, the jumpmaster will normally adjust the SPOT in the direction of the DZ so the skydiver has sufficient altitude to

[12] Depending on the wind velocity, temperature and air density, a fully-loaded C182 will have a minimum climb rate of 500 – 800 fpm. The C208 Caravan will likely climb with wings level at 1000 fpm or more.
[13] To illustrate, before considering parachute forward speed, a tandem jumper in 20 knot winds will be blown laterally by the wind while descending 1000 feet. Therefore, even jumpers whose chutes open at altitude above the turbines will be blown east or east-north-east of the turbines before descending to an altitude that matches the highest height of the turbine blade. Furthermore, the skydivers will “fly” their chutes to the east even as they are “blown” in that direction, increasing the lateral separation from the turbines as they descend.
[14] This accounts for the altitude lost while the chute deploys.

maneuver to turn downwind from the DZ onto the base leg, and conduct a stabilized final approach into wind. This adjustment moves the SPOT yet further from the turbines. It is for these reasons that the operational safety analysts concluded that most skydivers would generally operate to the east of T4 and T5.

Table 3.1 – Spot Calculation

		Student	**Experienced**	**Expert Accuracy**
		25*	42*	20*
		1000/fpm	1400/fpm	800/fpm
MPH	**FtPM**	**2 minutes**	**1.5 minutes**	**3 minutes**
5	440	880	660	1320
10	880	1760	1320	2640
15	1320	2640	1980	3960
20	1760	3520	2640	5280
25	2200	4400	3300	6600
30	2640	5280	3960	7920
35	3080	6160	4620	9240
40	3520	7040	5280	10560

*Canopies have forward speed even in still air. These values represent typical forward speeds (e.g., 25 mph, 42 mph and 20 mph) which should be understood when estimating the distance that a skydiver will travel laterally over the ground while descending under the canopy.

The operational safety analysts considered a worse case situation which had the potential to cause a skydiver to strike one of the wind turbines. Occasionally a low level jet stream will result in abnormally strong winds at jump altitudes. When this happens, experienced skydivers might exit the aircraft at a SPOT west or southwest of the turbines[15]. Even when this occurs, the jumpers will be quickly blown by the strong winds to the east of Station Road at a safe crossing altitude. However, these strong low level winds *could* coincide with a parachute malfunction, causing the skydiver to descend to an abnormally low altitude west of Station Road or in the vicinity of the turbines. The probability of these two unusual circumstances occurring coincidentally would be unlikely, and the likelihood of the skydiver subsequently striking a turbine, rare. The jumper need only fly into wind and turn to avoid the turbine. Therefore, for this accident to occur, the skydiver would have to be so close to a turbine as to be unable to turn and land at one of the many open areas along either side of Station Road.

<u>Assessment of risk to skydivers</u>

The operational safety analysts determined that the risk of a skydiver colliding with one of the two turbines, or losing control while avoiding a turbine would be rare. They made this determination because:

- Most skydivers will exit the aircraft at a SPOT that will not place the skydiver in vertical proximity to either of the turbines;
- Low level jet streams do not occur often, and the associated strong winds would restrict the number of skydivers to those who are sufficiently experienced to manage a coincident chute malfunction; and

[15] When a low level jet stream exists, the surface winds will normally exceed the maximum permissible wind speeds for novice jumpers.

- The two turbines are spaced almost one-half kilometer apart, and are located where there are numerous suitable off-airport landing sites.

3.2.2 The turbine blades of T4 and T5 may cause turbulent air

a. Introduction

Turbulence is disrupted air flow. The free flow of air is affected by large geographical features, by pressure gradients, by temperature, and by air mass stability. All of these factors affect the air flow and cause turbulence and this type of turbulence is called ambient turbulence and is generally equal to 5% of the average wind speed. It is always present and pilots and skydivers must always adjust their approach to landing to respond to the ambient turbulence.

Electrical energy from a wind turbine is generated when the free flow of air imparts a force on the turbine's blades, which in turn applies torque on a generator. The wind turbine blades impart an equal torque to the free flow of air that passes over them, causing an induced turbulent air flow.

Studies have shown that turbine induced turbulence behind a horizontal axis turbine may extend from 10 to 16 rotor-diameters downstream from the turbine. A study of the free-flow air, the associated ambient turbulence and projected induced turbulence that could be generated by the proposed Wainfleet wind turbines was conducted by GL Garran Hassan in 2013. This study analysed the projected wind turbine induced turbulence for a variety of relevant wind speeds coming from a south-west and westerly direction towards the Colborne airport the, primary location of the DZ. The intent of this study was to conduct a review and analysis of the Wainfleet Project wind data. The study discovered that in all modeled cases the induced turbulence created by the proposed wind turbines would be less than 1% of the free flow of air prior to reaching a distance of 10 rotor-diameters or a distance of one kilometer. Though the modeling did not consider all turbulence conditions which may occur, the study is highly informative and one can deduct from its results that it is unlikely that induced turbulence would affect activities at the Colborne aerodrome.[16]

b. Potential risk to aircraft: Loss of control of aircraft on final approach or during flare to land

There are no aviation safety standards requiring minimum setbacks from runways that safeguard aircraft from turbine-generated air turbulence[17]. Furthermore, there is a paucity of research regarding the effects of turbulence – on aircraft operations, and particularly on skydiving operations. Until there is further research available, the operational safety analysts are inclined to agree with the advice of the United Kingdom Civil Aviation Authority (UK CAA), that the "analysis of turbulence can only be undertaken on a case-by-case basis, taking into account the proximity of the development and the type of aviation activity conducted"[18].

Pilots operating from Port Colborne may be exposed to small degrees of turbulent air, but only when there are strong winds from the west. In such circumstances, they would encounter the turbulence during the final segment of the approach, and during the flare and landing the aircraft.

Assessment of risk to skydiving aircraft

The operational safety analysts determined that the risk of losing control of the aircraft because of turbulent air would be rare. They made this determination because:

- The prevailing WSW wind direction will cause air turbulence to most often exist in areas where aircraft will not be operating;

[16] Garrad Hassan, Turbulence Analysis at the Proposed Wainfleet Wind Project, Document no. 800532-CAVA-T-01, August 29, 2013
[17] UK CAA CAP 764, section 8.3.
[18] UK CAA, CAP 764, section 8.7.

- Historical data indicates that westerly winds (i.e., winds from 260° to 280°) that could potentially cause turbulence in the low level airspace near the runway occurs only 12% of the time, and on average at speeds that would generate minimal turbulence near the runway[19];

- Westerly winds occur most frequently during the months of January and April, when there are few (April) or no (January) aircraft operations[20];

- The terrain and buildings between the turbines and the runway will deflect or dissipate turbulence to an unknown degree; and

- Pilots will employ existing practices to counter the effect of turbulence – a common characteristic of operating aircraft when landing or taking off.

It was suggested that if there were concerns about residual risk, they could be mitigated by placing some form of wind indicator (e.g. a raised streamer) near the approach end of the runway alongside the wind sock to warn pilots when air turbulence exists.

c. Potential risks to Skydivers: loss of control while maneuvering to land
strike the ground at excessive speed during the final turn

For the reasons described above (e.g., prevailing seasonal winds; the number, location and distance of the turbines, etc.) skydivers would rarely encounter turbine-generated air turbulence in the vicinity of the drop zone. However, when there are strong steady winds directly from the west, skydivers may encounter turbulence when maneuvering from a downwind position into wind for the landing. These turns into wind are normally initiated from a point 100 feet to 300 feet downwind of the landing target at an altitude of 100 feet to 150 feet AGL.[21]

Assessment of risk to skydivers

The operational safety analysts were hard-pressed to determine the risk resulting directly from turbine-induced air turbulence. There is an absence of consistent information regarding the effects of turbulence on even aircraft, let alone skydiving. They did note that there was only one recorded fatality to a skydiver as a result of a wind turbine, and that occurred in Germany in 2000, and was not related to air turbulence. They also noted that Canadian and International injury data to skydivers demonstrate a significant portion of fatalities and injuries occur when skydivers make the final turn for landing. In short, they noted that this phase of the jump currently exposes skydivers to considerable risk, and that turbulent air has the potential to increase that risk. They determined that with appropriate mitigation, the current level of risk would not be increased. They made this determination because:

- The induced turbulence generated by the turbines will normally extend close to the ground in a north-north east direction from the turbines, where skydivers will not be operating;

- The westerly winds which could cause turbulence in the vicinity of the drop zone only occur 12% of the year, and these conditions occur most often in January and April when there is very little skydiving;

- The westerly winds would need to be very strong and sustained for long periods of time for the turbulent air to be significant 1.7 kilometers from the turbines, and even so the GL

19 Garrad Hassan, 2013.
20 http://www.windfinder.com/windstats/windstatistic_port_colborne.htm
[21] Tandems normally initiate a stabilized turn from a higher altitude – approximately 300 feet AGL.

Garrad Hassan Technical Note suggests that induced turbulence would be less than 1% of the free flow air.

- Terrain, bushes, trees and buildings would dissipate the induced turbulence; and
- Skydivers would take the normal precautions they employ to mitigate other sources of turbulence when operating close to the ground.

The operational safety analysts assessed the following additional mitigation could effectively reduce any possible residual risk to a level as low are reasonably practicable:[22]

- Restrict jumps by novices when conditions conducive to air turbulence exist (e.g., strong westerly winds);
- Institute minimum final-turn altitudes for tandem and expert jumpers when air turbulence might exist;
- Design and install air turbulence indicators (similar to existing wind indicators) near the drop zone so skydivers are made aware of air turbulence; and
- Develop an alternative, emergency landing site on the airfield where skydivers can "divert" when they suspect air turbulence near the primary landing site.

3.3 Potentially increased risks resulting from T4 and T5

The hazards described below currently exist, and T4 and T5 would have the potential to increase the associated risks.

Parachute malfunctions currently occur, although infrequently[23]. When this happens, skydivers cutaway the main chute and deploy their reserve chute. The time spent completing this manoeuver may require the skydiver to land somewhere other than the designated landing area. The operational safety analysts determined that there would be *no increased risk* because:

- Of the very low probability of a malfunctioning chute coinciding with the skydiver being in close proximity to one of the turbines after deploying the reserve;
- The skydiver would have time to steer into wind, then turn to avoid the turbine; and
- Because of the reasons described in 3.2.1.

If there were concerns for novice jumpers, the risks of striking a turbine after a malfunction could be further mitigated by:

- Restricting SPOT locations for novice jumpers; and
- Increasing the altitude for the activation of AAD equipment on the primary chute, so skydivers would have more time to detect and respond to a malfunction.

An incapacitated skydiver might suffer more serious injury if he or she collided with a turbine that otherwise would not be present. The operational safety analysts determined that there would be *no increased risk* because of:

[22] In the world of safety-risk management the lowest level of risk attainable while still conducting the safety-critical operation is referred to as "a level as low as reasonably practicable, otherwise known as ALARP.
[23] It is estimated that as many as 10 malfunctions might occur annually at Skydive Burnaby.

- The infrequent occurrence of skydiver incapacitation;
- The very low likelihood of the incapacitated skydiver being in proximity to a turbine;
- The high likelihood of serious injury to the incapacitated skydiver, whether the individual struck the turbine or some other obstacle; and
- The procedures that currently exist or that would be introduced to ensure all skydivers remain clear of T4 and T5.

The risk of two skydivers colliding while approaching the DZ – a hazard that currently exists – would potentially be increased if there were turbulent air near the landing area. Collisions currently occur worldwide when skydivers at low altitudes focus on the landing area and lose awareness of other parachutists maneuvering to land. There would be potential for a collision to occur if one or more skydivers preparing to land were distracted after encountering turbulent air. The operational safety analysts determined that there would be *no increased risk* because:

- Of the low incidence of predicted air turbulence near the DZ;
- The current awareness by skydivers of the importance of 'situational awareness' during this critical phase of the jump; and
- Because of the mitigation described in 3.2.2.

4. CONCLUSION

For reasons noted herein, it was determined that the presence of turbines 4 and 5 of the proposed Wainfleet Wind Energy Project would not significantly increase safety-risks to the operation of Skydive Burnaby.

The rotating turbine blades will generate induced turbulence that will vary in strength and direction with changes in wind velocity. However, the strongest area of induced turbulence will be close to the turbine on the leeward side, and prevailing winds will normally cause the diminishing area of turbulence to exist where pilots and skydivers will not be operating. On those occasions when the winds are from 260 and 280 degrees magnetic, the induced turbulence will have decreased considerably across the intervening 1.7 kilometres between the turbines and the Colborne aerodrome. Terrain and man-made structures will further deflect or dissipate the turbulence. Residual risk – if it exists – will be effectively mitigated by pilots and skydivers conforming to best practices when operating low to the ground. To be prudent, new procedures could be instituted for pilots and skydivers to identify indicators of turbulent air so they can avoid it.

The turbines will add to the obstacles that pilots and skydivers currently face. However, operational procedures will assure Skydive Burnaby that aircraft and skydivers are seldom exposed to the physical presence of the turbines; and that pilots and skydivers (in particular) will avoid the towers and blades on those few occasions when they may find themselves in proximity to the turbines.

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APPENDIX A: OPERATIONAL SAFETY ANALYSTS

SMS Aviation Safety Inc. has provided customized services in aviation safety to an international clientele since 2001. The company is led by Terry Kelly who has 5,000 hours flying experience.

Terry Kelly has extensive experience in safety analysis acquired in numerous positions since 1984, including: an analyst in the former Canadian Aviation Safety Board (CASB); Superintendent, Safety Studies (CASB); Chief, Safety Studies in the Transportation Safety Board (TSB); and Director, Standards and Safety Studies in Transport Canada. In these positions he regularly devised methodologies and surveys to collect and analyze safety data; headed multi-disciplined teams to analyze operational issues; and prepared reports and recommendations on public policy issues that were addressed to Canadian Ministers of Parliament.

Terry has experience in investigating aviation accidents, and in conducting safety reviews, safety surveys, safety risk assessments and operational evaluations.

He has led and conducted over thirty operational safety-risk assessments in the past fifteen years. Some examined wildlife management at airports (e.g., YVR; YYC). Others studied the introduction of complex technical and operational systems (e.g., RVSM in Canadian Northern Domestic Airspace). Yet others examined issues related to sensitive policy areas spanning inter- and intra-departmental boundaries, including: a Safety Review of the Federal Government's plans to introduce a wildlife conservation area on and around the Vancouver International Airport; the Transition to a Commercialized Air Navigation System; the use of single-engine, turbo-prop aircraft in passenger-carrying IFR operations; and Land and Hold Short Operations (LAHSO) in Canada. In early 2008 he conducted the first operational risk assessment in Canada of a wind farm located very close to a NAV CANADA radar site in New Brunswick. He has subsequently conducted a number of such studies, including an assessment of the risks related to three adjacent projects for the construction of more than 180 wind turbines on land under some of the most complex airspace in Canada.

Hugh Loraine has extensive experience as a commercial pilot, an air traffic controller and ATC manager, a safety investigator and a System Safety Officer with Transport Canada. Hugh actively flies for a commercial air service, and in his spare time, tows gliders for a soaring club.

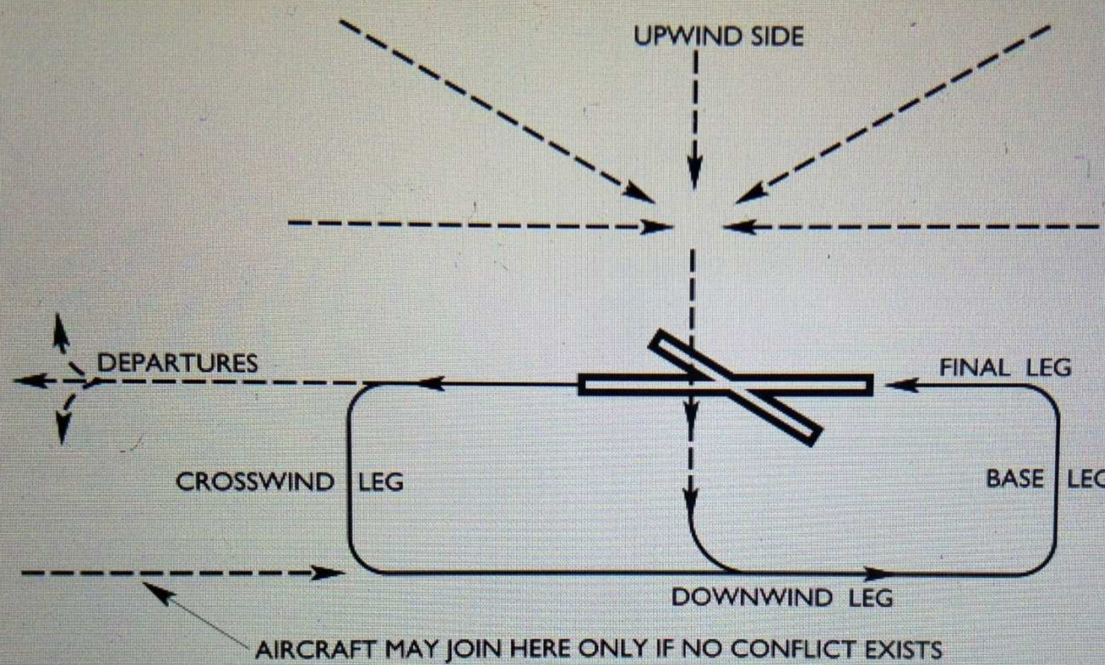
Trevor Owen was a professional pilot, Air Force officer and Civil Aviation Inspector with Transport Canada. He has considerable experience in assessing the safety of aviation organizations and operations. Trevor acts as an independent consultant concerning aviation issues, and has been employed by several governmental agencies and private companies to conduct safety assessments of small air operators.

APPENDIX B:
SUMMARY OF FINDINGS

Hazard	Risk Mitigation	Resultant Likelihood of occurrence
Potential risks to aircraft: • Collision with turbine • Loss of control while maneuvering to avoid a turbine	• Location of wind turbines published their location in NOTAMS (notice-to-airmen); • Wind turbines physically lighted in accordance with Transport Canada (TC) standards; • Location of wind turbines marked on local and regional aviation maps; and • Location of wind turbines highlighted in the Canada Flight Supplement (CFS) • Current standard operating procedures and potential future procedures restrict aircraft from flying in the vicinity of the turbines.	Rare
Potential risks to Skydivers: • collision with turbine towers or blades under normal circumstances • loss of control while maneuvering near a turbine	• None required. Standard operating procedures currently employed are sufficient to achieve a low level of risk,	Rare
Potential risk to aircraft resulting from induced turbulence: • Loss of control of aircraft on final approach or during flare to land	• None required. (However, the installation of placing some form of wind indicator (e.g. a raised streamer) near the approach end of the runway alongside the wind sock to warn pilots when air turbulence exists could reduce the likelihood even further.	Rare to very rare
Potential risks to Skydivers resulting from induced turbulence: • loss of control while maneuvering to land • strike the ground at excessive speed during the final turn	• Restrict jumps by novices when conditions conducive to air turbulence exist (e.g., strong westerly winds); • Institute minimum final-turn altitudes for tandem and expert jumpers when air turbulence might exist; • Design and install air turbulence indicators (similar to existing wind indicators) near the drop zone so skydivers are made aware of air turbulence; and • Develop an alternative, emergency landing site on the airfield where skydivers can “divert” when they suspect air turbulence near the primary landing site.	ALARP
Risk associated with parachute opening malfunction: • collision with turbine towers or blades	Generally, no mitigation required, since current standard operating procedures are sufficient to maintain current level of risk. However, further reductions in risk could be achieved by: • Restricting SPOT locations for novice jumpers; and • Increasing the altitude for the activation of AAD equipment on the primary chute, so skydivers would have more time to detect and respond to a malfunction.	Rare to very rare
Risk associated with an incapacitated skydiver • collision with turbine towers or blades	None required since current operating practices are sufficient mitigation to maintain current risk level.	Very rare
Risk of two skydivers colliding while approaching the DZ	None required since current operating practices are sufficient mitigation to maintain current risk level.	Rare

APPENDIX C:
DIAGRAM OF A STANDARD TRAFFIC PATTERN

Figure 4.6–Standard Left-hand Circuit Pattern



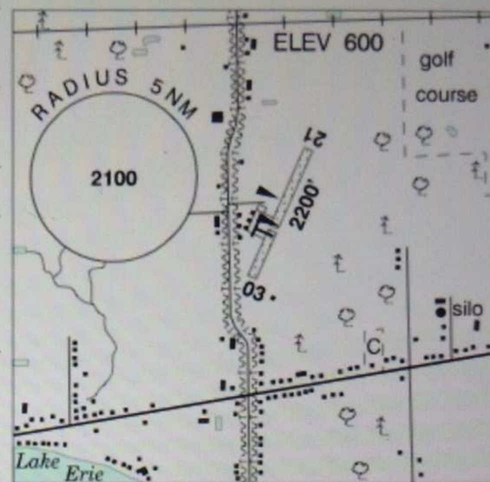
NOTES 1: The circuit is normally flown at 1 000 ft AAE.

2: If a right-hand circuit is required in accordance with CAR 602.96, the opposite of this diagram is applicable.

APPENDIX D:
EXCERPT FROM CFS/GPH 205

PORT COLBORNE ON **CPE5**

REF	N42 52 39 W79 21 10 4.8W 10°W UTC-5(4) Elev 600´ A5000
OPR	Skydive Burnaby 905-899-1528 Reg PPR
PF	B-1 C-2,3,4,5,6
FLT PLN **FIC**	NOTAM FILE CYSN London 866-WXBRIEF (Toll free within Canada) or 866-541-4104 (Toll free within Canada & USA)
SERVICES **FUEL** **OIL** **S**	 100LL All 1,4,5
RWY DATA **RCR**	Rwy 03/21 2200x75 turf Thld 03 displ 800´. Opr No win maint. Rwy soft when wet.
COMM **ATF** **A/G**	 tfc 123.2 5NM 3600 ASL 122.9
PRO	Rgt hand circuits Rwy 21 (CAR 602.96). Possible tfc conflict from A/D 2NM E. Ocsl release of parachutes Mon-Fri fr 500´ above water aprx 1NM S, announced on ATF. CYA513(P) activated by NOTAM when parachuting in progress btwn 2800-14,500 ASL.



Information contained in the excerpt is effective 27 June 2013.

APPENDIX: E

PARACHUTING FATALITIES

Table 1 - Fatalities per Total Jumps							
	U.S.	U.S.	U.S.	Canada	Canadian accident detail		
Year	**Skydiving Fatalities in U.S.**	**Estimated Annual Jumps**	**Fatalities Per 1000 Jumps**	**Skydiving Fatalities in Canada**	**Category & Cause (1)**	**(2)**	**(3)**
2012	19	3.1 million	0.006	1	Landing: Hook turn during landing		
2011	25	3.1 million	0.008	3	Landing: Low altitude deployment of reserve chute	Landing: Low turn during landing	Unknown: Separated from harness
2010	21	3.0 million	0.007	1	Landing: Hard landing during low turn		
2009	16	3.0 million	0.005	2	No Pull: Main chute not deployed; reserve chute not deployed.	No Pull: reserve chute not deployed.	
2008	30	2.6 million	0.012	2	Landing: Landed in electrical wires	Landing: Low turn during landing	
2007	18	2.5 million	0.007	2	Malfunction: Cutaway chute at low altitude	Malfunction: Released toggle.	
2006	21	2.5 million	0.008	0			
2005	27	2.6 million	0.01	2	Unknown: Unknown	No Pull: reserve chute not deployed	

Source: USPA.COM and DROPZONE.COM

APPENDIX: F

AERIAL PHOTO OF COLBORNE AERODROME

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